Detecting and recording the calls produced by butterfly caterpillars and ants

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Introduction

Chirping crickets, shrilling cicadas, and buzzing flies are familiar examples of how insects communicate with sound. Some sounds that are fundamentally important to insect communication systems may, however, be inaudible to the human ear because they are produced at very low amplitudes (Gogala 1985; Markl 1983). For example, low amplitude airborne sounds produced by wing-flapping may provide vital cues for species specific mate recognition in drosophilid flies (Hoy *et al.* 1988), or ants may use substrate-borne vibrations to recruit nestmates to a resource (Baroni-Urbani *et al.* 1988). Although many insects may produce low amplitude signals in their communication systems, investigators require instruments to detect them before they can be studied.

Studies concerned with low-amplitude insect sounds are generally conducted under laboratory conditions, and employ bulky and typically expensive detection and recording instruments. However, a particle velocity microphone and amplifier was recently designed by H. Bennet-Clark (1984) that is inexpensive, portable, and shows great promise as a tool for discovering and studying low amplitude insect sounds (e.g., Hunter 1987; Hoy *et al.* 1988). Using the Bennet-Clark particle velocity microphone I have been able to investigate the low amplitude, substrate-borne calls produced by riodinid and lycaenid butterfly caterpillars that form symbioses with ants (DeVries 1990; 1991). The purpose of this paper is to briefly describe my methods and experience in detecting and recording caterpillar and ant calls. My aim is to encourage a broader interest in the documentation and study of these calls - an area of biology where much remains to be explored.

The microphone and amplifier

Plans for the particle velocity microphone are found in Bennet-Clark (1984). My equipment was constructed by a friend, and modified from the original design in three ways: 1) the microphone itself is simply wrapped in flattened brass mesh (Fig 1a), 2) the monitor switch is spring loaded to the off position to save battery power, 3) the amplifier was fitted into an 140 x 75 x 32 mm aluminum box, and 4) the amplifier was fitted to accept both sizes of headphone jacks (Fig. 1b). To reduce bulk I use the smallest set of headphones I could find - not the finest, but easy to pack. Thus, all the components of the amplifier and microphone are compacted for easy transport.

The recording stage

A serviceable recording stage can be made of two plastic Petri dishes with a 75 mm diameter circle cut from their centers (I have used both circular and rectangular types). The opposing bottoms of the Petri dishes are fitted together and held in place with 4 nylon screws and nuts, with a circular membrane of paper or transparent mylar sandwiched between the Petri dishes to provide the recording substrate (Fig 1a). The interchangeable nature of the membrane will allow recording of caterpillar calls as they are transmitted through different substrate materials (e.g., plant material, metal, paper, wood).

The stage is supported above a table by an adjustable set of gator-jaw clamps ('lab hands') that are available from laboratory or electronic supply houses. One of the gator jaws holds the stage, and the other jaw is used to hold the microphone against the membrane from below (Fig 1a&b). The user may want to make a more sophisticated recording stage set-up, but the one described here is inexpensive, compact, and durable in the field.

After connecting the microphone to the amplifier, detecting or recording caterpillar calls is done simply by placing a caterpillar on the membrane and allowing it to walk (be patient as it may take a few minutes) and monitoring the activity with the headphones. A pair of entomological forceps is useful for caterpillar manipulations. It is advisable to occasionally check that the microphone is placed correctly against the membrane (Fig.1a). The cleanest signals are obtained from lycaenid caterpillars that have been turned on their back - it eliminates the scratching sound produced by their tarsi gripping the membrane while walking. In the case of riodinid caterpillars, however, they quickly right themselves, and typically produce a lot of high frequency background noise.

Recording

A caterpillar call can be recorded on any tape recorder, but those with an adjustable gain yield the best results; the automatic gain on some tape recorders tends to increase unwanted noise on the tape. For my own work I use a Marantz PMD - 420 portable cassette recorder / player and record with high bias tape. While recording a call the tape recorder needs to be isolated from the surface where the recordings are being made. Otherwise the microphone will pick up the motor sounds of the tape recorder transmitted through the table. I do this by cushioning the recorder on a 50mm thick foam pad placed on a chair or box isolated from the table

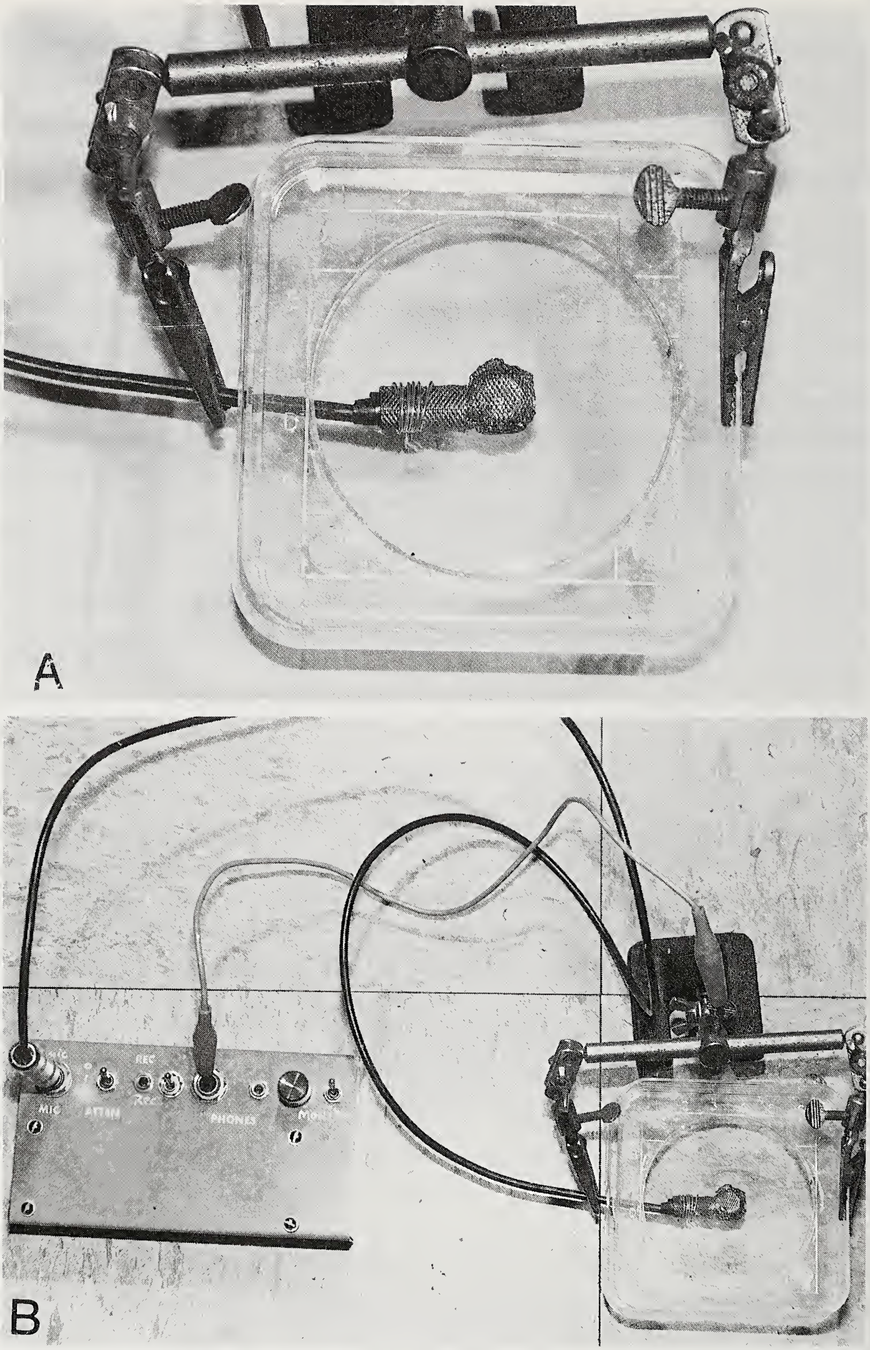

Figure 1: (A) Detail of the recording stage showing the gator-jaws, modified Petri dishes, transparent mylar membrane, and particle velocity microphone set up for recording caterpillar calls. (B) The amplifier, particle velocity microphone and recording stage set-up. The tape recorder and headphones are not connected. An idea of scale can be gained from the 31cm square floor tiles in background.

surface holding the microphone, amplifier, and recording stage. Secondly, recording extraneous substrate-borne signals generated from touching the table, the wires, or the amplifier (the microphone is *extremely* sensitive) may be minimized by placing the recording stage on a piece of foam rubber. Finally, a ground wire connected from the gator-jaw stage support to the amplifier will further reduce or eliminate line hum (Fig 1b).

Suggestions

A major consideration in obtaining good recordings is the inherent sensitivity of the equipment - ambient and incidental noise can be a problem. In many instances the user will find that in addition to caterpillar calls, the recordings will contain a seeming endless variety of other sounds: wind, rain, bird, insect, and frog calls, vibrations of people walking in the building, and perhaps most pestiferous, air conditioning devices and 50-60 cycle electrical hum. Thus, it is an advantage to record in a place where the investigator has some control over the environment. Generally I record late at night in a building where the inhabitants have left (or have been driven off) with the source of electricity shut off at the mains, and work with a battery-operated headlamp for illumination. Under conditions where the investigator cannot switch off the electrical mains, and experiences severe electrical interference, a copper mesh Faraday cage may be required. Field recordings are best made in a shed or tent during the day to minimize picking up the calls of nocturnal insects and amphibians on the recordings . However, at times rain, wind, and animal calls can be an annoying problem. Finally, keeping the 9 volt amplifier battery fresh will help reduce hum and flutter.

The silk normally laid down by walking caterpillars will build up on the membrane after extended use and allow caterpillars a firm grip on the substrate and generate unwanted noise as they walk. This source of irritating high frequency noise can be minimized or avoided by replacing or cleaning the stage membrane regularly . Using a mylar membrane will result in cleaner recordings because it minimizes the ‘pops’ produced by the caterpillar’s tarsi hooking into the substrate, it is easily cleaned, and it has the added advantage of facilitating visual inspection of the microphone position (Fig 1b).

Ants are obviously important to the study of myrmecophilous caterpillars. Recording ant stridulations must be done in such a way as to avoid the excessive noise generated by the legs scrambling on the membrane. Some species will happily walk on the membrane and produce substrate stridulations or tapping. The industrious investigator may set up the microphone such that it contacts the side of a container holding a captive ant colony. However, the few times I tried this the typical frenzied activity of an ant colony came through loud and clear, thus making the recordings too cluttered for individual analysis. Holding ponerine or myrmecine ants with forceps such that the legs are completely restrained (or removed), and touching the head or abdomen against the membrane gives good recordings of 'alarm' stridulations.

The equipment described here, the heart of which is the Bennet-Clark particle velocity microphone, has made it feasible for me to detect and record caterpillar, pupae, ant and beetle sounds in Ecuador, Panama, Costa Rica, Belize, the USA, Madagascar, England and Germany. As simple as it is, my equipment has endured a lot of field time under what may be termed 'not exactly sterile laboratory conditions', yet I have not experienced any appreciable problems with it. I hope that these methods described here will be expanded and improved upon through wider use in the investigations of low amplitude insect sounds. Certainly they have helped our understanding of the role of sound in caterpillar-ant symbioses.

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